(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 300 844 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.04.2003 Bulletin 2003/15

(51) Int Cl.[7]: **G11B 20/10**

(21) Application number: **03000514.4**

(22) Date of filing: **27.10.1999**

(84) Designated Contracting States:
DE FR GB

(30) Priority: **27.10.1998 JP 30486998**

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
99120880.2 / 0 997 901

(71) Applicant: **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
Kadoma-shi, Osaka 571-8501 (JP)

(72) Inventors:
- **Horibe, Ryusuke**
  Osaka 573-0071 (JP)
- **Kawakami, Shinichi**
  Kishiwada-shi, Osaka 596-0045 (JP)
- **Aoki, Kazuhiro**
  Suita-shi, Osaka 565-0824 (JP)
- **Kanekami, Youichi**
  Mishima-gun, Osaka 618-0001 (JP)

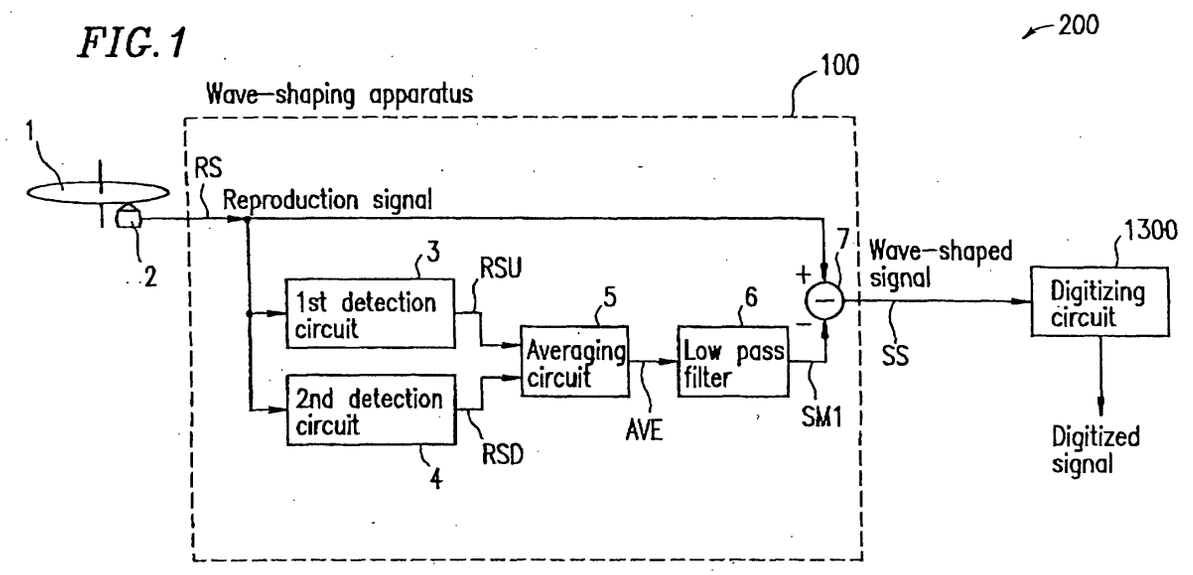
(74) Representative: **Schwabe - Sandmair - Marx**
Stuntzstrasse 16
81677 München (DE)

Remarks:
This application was filed on 09 - 01 - 2003 as a divisional application to the application mentioned under INID code 62.

(54) Wave-shaping apparatus and reproduction singal processing apparatus including the same

(57) A wave-shaping apparatus includes a first detection circuit for detecting a reproduction signal reproduced from an optical disk by an optical pickup circuit using a first detection time constant to detect an upper envelope of the reproduction signal; a second detection circuit for detecting the reproduction signal using a second detection time constant to detect a lower envelope of the reproduction signal; an averaging circuit for putting a weight represented by a weighting coefficient to each of the upper envelope and the lower envelope to calculate an average value of each of the upper envelope and the lower envelope; and a subtraction circuit for subtracting a signal corresponding to the average value from the reproduction signal to output a wave-shaped signal.

FIG. 1



EP 1 300 844 A1

Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION:

[0001] The present invention relates to a wave-shaping apparatus and a reproduction signal processing apparatus including the same, and specifically a wave-shaping apparatus for optimally performing digitization or A/D (analog/digital) conversion of a reproduction signal obtained by an optical pickup circuit, and a reproduction signal processing apparatus including the same.

2. DESCRIPTION OF THE RELATED ART:

[0002] Recently, optical disks are being used in various conditions and stored in various manners. Under the circumstances, surfaces of optical disks are often scratched or exposed to dust. In order to read information from an optical disk having dust or scratches, a high precision signal determination is required.

[0003] Especially, an optical disk having information at a high density such as a DVD (digital versatile disk) has an inferior SNR (signal/noise ratio) at the shortest pit portion. Accordingly, it is required to minimize errors when a signal is digitized.

[0004] Information recording to a CD (compact disk) is performed by EFM (eight to fourteen modulation), and information recording to a DVD is performed by 8-16 modulation. These modulation systems make the spectrum of recording pattern to the disk substantially DC component-free. In order to make use of such characteristics of these modulation systems, a reproduction signal is usually digitized by a digitizing circuit for controlling the slicing level of the signal by performing negative feedback control, so that the duty ratio of the digitized signals is 50:50.

[0005] With reference to Figure **13A**, a digitizing circuit **1300** will be described.

[0006] An optical pickup circuit **2** outputs a reproduction signal RS obtained from an optical disk **1**. The reproduction signal RS is capacitance-coupled by a capacitor C and supplied with a prescribed bias voltage of, for example, VCC/2. The resultant signal is input to a negative (-) input terminal **110A** of a comparator **110** and compared with a slicing level which is input to a positive (+) input terminal **110B** of the comparator **110.** Thus, a digitized signal DG1 is output from the comparator **110.**

[0007] A charge pump **101** is driven, i.e., the potential of a charge capacitor **102** is increased or decreased, in accordance with the polarity of the digitized signal DG1 output from the comparator **110**. A charge voltage stored in the charge capacitor **102** is current-amplified by a buffer **103** and ripple-removed by a low pass filter **104**. Then, the resultant signal is input to the positive input terminal **110B** of the comparator **110.**

[0008] For example, when the potential of the negative input terminal **110A** is higher than the potential of the positive input terminal **110B,** the output level from the comparator **110** is 0. Then, a charge pump **101A** is turned on to raise the potential of the charge capacitor **102.** Thus, the potential of the positive input terminal **110B** of the comparator **110** is raised. In this manner, negative feedback control is performed so that the difference between the potential of the positive input terminal **110B** and the potential of the negative input terminal **110A** becomes 0.

[0009] When the potential of the negative input terminal **110A** is lower than the potential of the positive input terminal **110B,** a charge pump **101B** is turned on to reduce the potential of the charge capacitor **102.** Thus, the potential of the positive input terminal **110B** of the comparator **110** is lowered. In this manner, negative feedback control is performed so that the difference between the potential of the positive input terminal **110B** and the potential of the negative input terminal **110A** becomes 0.

[0010] Figure **13B** is a waveform diagram of a high frequency reproduction signal RS. When such a high frequency reproduction signal RS is input to the digitizing circuit **1300**, a negative feedback digitizing slicing level SL is controlled so that the duty ratio of the "0" level L0 and the "1" level of the digitized signal DG1 output from the digitizing circuit **1300** becomes 50:50.

[0011] A response ability of the negative feedback control is determined by the driving current value of the charge pump **101,** the capacitance of the charge capacitor **102,** and the time constant of the low pass filter **104.**

[0012] When an optical disk has defects such as dust or scratches, laser light from an optical pickup circuit is blocked by the dust or scratches. Accordingly, the level of the reproduction signal is significantly fluctuated in terms of both direct current or alternate current. In order to accurately digitize the reproduction signal despite such changes, the digitizing circuit **1300** needs to have a higher response ability so as to follow the changes.

[0013] However, the spectrum of recording pattern to the optical disk is not completely DC component-free around a defect change frequency (several kilohertz or less). Thus, the cut-off frequency of the low pass filter **104** needs to be raised to improve the response ability of the digitizing circuit **1300**. In such a case, a DC fluctuation component of the reproduction signal is mixed into a negative feedback signal, i.e., the signal input to the positive input terminal **110B** as an external disturbance. This prevents accurate digitization, and a data slicing error occurs and generation of jitters is increased.

[0014] Figure **14** shows a circuit designed for alleviating the data slicing error. The reproduction signal RS is passed through a high pass filter **105**, before being input to the digitizing circuit **1300**, to remove a low frequency band fluctuation component, so that the reproduction signal RS has a line of symmetry between the

upper half and the lower half even when the signal level is fluctuated by defects. In this manner, the control load performed by the digitizing circuit **1300** is alleviated and thus the data slicing error is alleviated.

[0015] However, such a circuit removes the low frequency band fluctuation component in a steady state, i. e., even when there is no defect. Therefore, a data slicing error occurs by the lack of information provided by the low frequency band fluctuation component and the generation of jitters is increased.

SUMMARY OF THE INVENTION

[0016] According to one aspect of the invention, a wave-shaping apparatus includes a first detection circuit for detecting a reproduction signal reproduced from an optical disk by an optical pickup circuit using a first detection time constant to detect an upper envelope of the reproduction signal; a second detection circuit for detecting the reproduction signal using a second detection time constant to detect a lower envelope of the reproduction signal; an averaging circuit for putting a weight represented by a weighting coefficient to each of the upper envelope and the lower envelope to calculate an average value of each of the upper envelope and the lower envelope; and a subtraction circuit for subtracting a signal corresponding to the average value from the reproduction signal to output a wave-shaped signal.

[0017] In one embodiment of the invention, the wave-shaping apparatus further includes a low pass filter for smoothing the average value to output a smoothing signal. The subtraction circuit subtracts the smoothing signal from the reproduction signal.

[0018] In one embodiment of the invention, the weighting coefficient is 1:1.

[0019] In one embodiment of the invention, the weighting coefficient is determined based on an asymmetry quantity of the reproduction signal.

[0020] In one embodiment of the invention, the wave-shaping apparatus further includes an asymmetry detection circuit for detecting the asymmetry quantity.

[0021] In one embodiment of the invention, at least one of the first detection time constant and the second detection time constant is determined to be substantially in proportion to a diameter of a light spot on the optical disk.

[0022] In one embodiment of the invention, at least one of the first detection time constant and the second detection time constant is determined to be substantially in inverse proportion to a reproduction linear velocity of the optical disk.

[0023] In one embodiment of the invention, a cutoff frequency of the low pass filter is determined to be substantially in inverse proportion to a diameter of a light spot on the optical disk.

[0024] In one embodiment of the invention, a cutoff frequency of the low pass filter is determined to be substantially in proportion to a reproduction linear velocity of the optical disk.

[0025] In one embodiment of the invention, the wave-shaping apparatus further includes a dropout detection circuit for detecting a dropout indicating a decrease in an amplitude of the reproduction signal, wherein when the dropout is detected by the dropout detection circuit, at least one of the first detection time'constant and the second detection time constant is set to be shorter than the time constant when no dropout is detected.

[0026] In one embodiment of the invention, the wave-shaping apparatus further includes a dropout detection circuit for detecting a dropout indicating a decrease in an amplitude of the reproduction signal, wherein when the dropout is detected by the dropout detection circuit, the cutoff frequency of the low pass filter is set to be higher than the time constant when no dropout is detected.

[0027] According to one aspect of the invention, the fluctuation of a reproduction signal caused when an optical disk has a defect is suppressed. Thus, the control load of a digitizing circuit is significantly alleviated. As a result, data slicing errors are significantly reduced without increasing the jitters in a steady-state reproduction.

[0028] According to another aspect of the invention, the control load of a digitizing circuit is significantly alleviated and data slicing errors are significantly reduced without increasing the jitters in a steady-state reproduction with a relatively simple structure.

[0029] According to still another aspect of the invention, the weighting coefficient provided to upper and lower envelopes used by an averaging circuit for calculating an average value thereof is determined to be substantially in proportion to an asymmetry quantity of the reproduction signal. Therefore, the control load of a digitizing circuit is significantly alleviated regardless of whether the writing conditions of data to the optical disk (e.g., the diameter of the light spot), and data slicing errors are significantly reduced without increasing the jitters in a steady-state reproduction.

[0030] According to still another aspect of the invention, wave-shaping is optimally performed based on the diameter of the light spot in the optical disk. Thus, data slicing errors are significantly reduced without increasing the jitters in a steady-state reproduction.

[0031] According to still another aspect of the invention, wave-shaping is optimally performed based on the reproduction linear velocity of the optical disk. Thus, data slicing errors are significantly reduced without increasing the jitters in a steady-state reproduction.

[0032] According to still another aspect of the invention, the wave-shaping performance when the optical disk has a defect is improved while and the generation of jitters when the optical disk has no defect is not deteriorated.

[0033] Thus, the invention described herein makes possible the advantage of providing (1) a wave-shaping apparatus for alleviating the load of a digitizing circuit and significantly decreasing the generation of jitters,

and a reproduction signal processing apparatus including such a wave-shaping apparatus; and (2) a wave-shaping apparatus for accurately digitizing a reproduction signal even when the level of the reproduction signal obtained from an optical disk significantly fluctuates by a defect on the optical disk as well as when the optical disk has no defect, and a reproduction signal processing apparatus including such a wave-shaping apparatus.

[0034] These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035]

Figure **1** is a block diagram illustrating a structure of a reproduction signal processing apparatus in a first example according to the present invention;

Figure **2A** is a diagram illustrating an exemplary waveform of a reproduction signal obtained from an optical disk having a defect;

Figure **2B** is a diagram illustrating an average value obtained by performing weighting to the waveform shown in Figure **2A;**

Figure **2C** is a diagram illustrating a fluctuation component included in the reproduction signal shown in Figure **2A**;

Figure **2D** is a diagram illustrating a waveform obtained by wave-shaping the reproduction signal shown in Figure **2A**;

Figure **3** is a block diagram illustrating an exemplary structure of an averaging circuit shown in Figure **1**;

Figure **4A** is a diagram illustrating a frequency spectrum of a reproduction signal without being wave-shaped;

Figure **4B** is a diagram illustrating a frequency spectrum of a reproduction signal obtained by the reproduction signal processing apparatus shown in Figure **1**;

Figure **5** is a block diagram illustrating an exemplary structure of the average structure shown in Figure **1** when a weighting coefficient is 1:1;

Figure **6** is a block diagram illustrating a structure of a reproduction signal processing apparatus in a second example according to the present invention;

Figure **7A** is a diagram illustrating an exemplary waveform of a reproduction signal obtained when asymmetry occurs;

Figure **7B** is a diagram illustrating an average value obtained by performing weighting to the waveform shown in Figure **7A**;

Figure **7C** is a diagram illustrating a fluctuation component included in the reproduction signal shown in Figure **7A**;

Figure **7D** is a diagram illustrating a waveform obtained by wave-shaping the reproduction signal shown in Figure **7A;**

Figure **8** is a block diagram illustrating a structure of an asymmetry detection circuit shown in Figure **6;**

Figure **9A** is a diagram illustrating a light spot having a relatively large diameter passing through a detect on an optical disk;

Figure **9B** is a diagram illustrating a decrease in the level of the reproduction signal when the light spot shown in Figure **9A** passes through the detect;

Figure **9C** is a diagram illustrating a light spot having a relatively small diameter passing through a detect on an optical disk;

Figure **9D** is a diagram illustrating a decrease in the level of the reproduction signal when the light spot shown in Figure **9C** passes through the detect;

Figure **10A** is a diagram illustrating a fluctuation of the reproduction signal when the reproduction linear velocity of the optical disk is normal;

Figure **10B** is a diagram illustrating a fluctuation of the reproduction signal when the reproduction linear velocity of the optical disk is higher than the normal linear velocity;

Figure **11** is a block diagram illustrating a structure of a reproduction signal processing apparatus in a third example according to the present invention;

Figure **12** is a block diagram illustrating a structure of another reproduction signal processing apparatus in a third example according to the present invention;

Figure **13A** is a block diagram illustrating a structure of a digitizing circuit;

Figure **13B** is a diagram illustrating a high frequency reproduction signal input to the digitizing circuit; and

Figure **14** is a block diagram illustrating a structure of a conventional wave-shaping apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0036] Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

(Example 1)

[0037] A reproduction signal processing apparatus **200** in a first example according to the present invention will be described with reference to Figure **1**. Figure **1** is a block diagram of the reproduction signal processing apparatus **200**. As shown in Figure **1**, the reproduction signal processing apparatus **200** includes a wave-shaping apparatus **100** and a digitizing circuit **1300**.

[0038] A signal recorded on an optical disk **1** is reproduced by an optical pickup circuit **2** as a reproduction signal RS.

[0039] The wave-shaping apparatus **100** includes a first detection circuit **3** for detecting the reproduction signal RS from the optical pickup circuit **2** at a prescribed time constant and thus detecting an upper envelope RSU, a second detection circuit **4** for detecting the reproduction signal RS from the optical pickup circuit **2** at a prescribed time constant and thus detecting a lower envelope RSD, an averaging circuit 5 for finding an average value AVE of the upper envelope RSU and the lower envelope RSD, a low pass filter **6** for smoothing the AVE obtained by the averaging circuit **5** to output a smoothing signal SM1, and a subtraction circuit **7** for subtracting the smoothing signal SM1 from the reproduction signal RS to output a wave-shaped signal SS. The digitizing circuit **1300** digitizes the wave-shaped signal SS to output a digitized signal.

[0040] With reference to Figures **2A** through **2D,** an exemplary operation of the wave-shaping apparatus **100** will be described.

[0041] As described above, a signal stored in the optical disk **1** (Figure **1**) is read by the optical pickup circuit **2** as a reproduction signal RS. When the optical disk **1** has a defect such as, for example, a scratch, the reproduction signal RS includes a disturbance D1 as shown in Figure **2A.**

[0042] When the reproduction signal RS is directly input to the digitizing circuit **1300**, the reproduction signal RS is digitized with a negative feedback digitizing slicing level SL1, which follows an average vale or the upper envelope RSU and the lower envelope RSD or the vicinity thereof. However, when the disturbance D1 caused by a defect has an excessively short cycle the negative feedback digitizing slicing level SL1 cannot appropriately follow the disturbance D1, resulting in a slicing error.

[0043] In order to avoid such an inconvenience, the reproduction signal processing apparatus **200** includes the above-described elements and operates as follows.

[0044] Referring to Figure **2A,** the first detection circuit **3** (Figure **1**) detects the reproduction signal RS from the optical pickup circuit **2** and detects the upper envelope RSU. The second detection circuit **4** (Figure **1**) detects the reproduction signal RS from the optical pickup circuit **2** and detects the lower envelope RSD.

[0045] Referring to Figure **2B**, the averaging circuit **5** puts a weight represented by a weighting coefficient M: N to the upper envelope RSU and the lower envelope RSD to calculate the average value AVE.

[0046] Referring to Figure **2C,** the low pass filter **6** removes a noise component included in the average value AVE and extracts a hazardous DC fluctuation component included in the reproduction signal RS obtained when the optical disk (Figure **1**) has a defect. The signal containing substantially only the extracted component is output as a smoothing signal SM1.

[0047] Referring to Figure **2D**, the subtraction circuit **7** subtracts the smoothing signal SM1 from the reproduction signal RS to output a wave-shaped signal SS which has a lines of symmetry between the upper half and the lower half.

[0048] When the wave-shaped signal SS obtained as a result of such pre-processing is input to the digitizing circuit **1300**. the wave-shaped signal SS is digitized with a negative feedback digitizing slicing level SL2. The negative feedback digitizing slicing level SL2 does not substantially fluctuate even when the disturbance D1 caused bv the defect has an excessively short cycle ana can appropriately follow the disturbance D1. Thus, slicing errors are significantly reduced. Figure **3** shows an exemplary structure of the averaging circuit **5**. As shown in Figure **3**, the averaging circuit **5** can be realized by a simple structure.

[0049] With reference to Figures **4A** and **4B,** a frequency spectrum of the reproduction signal RS will be described.

[0050] Figure **4A** shows the frequency spectrum obtained when the reproduction signal RS is processed using a high pass filter **105** described with reference to Figure **14**. As shown in Figure **4A,** a component represented by area A1 is removed from the reproduction signal RS represented by area S by the high pass filter **105**. Generation of jitters caused by the lack of the component represented by area A1 is increased.

[0051] Figure **4B** shows the frequency spectrum obtained when the reproduction signal RS is processed by the reproduction signal processing apparatus **200**. As shown in Figure **4B**, a component represented by an area as small as area B1 is removed from the reproduction signal RS. Thus, the generation of jitters can be minimized. As a result, the slicing performance obtained when the light beam passes through the defect of the optical disk **1** (Figure **1**) is improved while the generation of jitters when the optical disk **1** has no defect is not deteriorated.

[0052] Where the weight coefficient M:N provided by the averaging circuit **5** to the upper and lower envelopes for finding the average value AVE is 1:1, an averaging circuit having a simple structure is obtained. Such an average circuit **5A** is shown in Figure **5**.

(Example 2)

[0053] Figure **6** is a block diagram of a reproduction signal processing apparatus **200A** in a second example according to the present invention. Identical elements previously discussed with respect to Figure **1** bear identical reference numerals and the descriptions thereof will be omitted. The reproduction signal processing apparatus **200A** includes a wave-shaping apparatus **100A** and the digitizing circuit **1300.**

[0054] The wave-shaping apparatus **100A** includes an asymmetry detection circuit **8** in addition to the elements shown in Figure **1**. The weighting coefficient M:N to the upper and lower envelopes used by the averaging circuit **5** for calculating the average value AVE is determined to be substantially in proportion to an asymmetry quantity of the reproduction signal RS.

[0055] Asymmetry is usually generated under certain disc cutting conditions or recording conditions. When a recording pit tends to be written to be larger than a prescribed reference pit, the negative feedback digitizing slicing level to realize a post-digitization duty ratio of 50:50 is offset upward (or downward) from an intermediate level of the reproduction signal. When a recording pit tends to be written to be smaller than the prescribed reference pit, the negative feedback digitizing slicing level to realize a post-digitization duty ratio of 50:50 is offset downward (or upward) from the intermediate level. The offset amount of the negative feedback digitizing slicing level relative to the intermediate level of the reproduction signal RS is referred to as the "asymmetry quantity".

[0056] With reference to Figures **7A** through **7D**, a frequency spectrum of the reproduction signal RS will be described.

[0057] Figure **7A** shows the frequency spectrum obtained when the asymmetry occurs. As shown in Figure **7A**, a negative feedback digitizing slicing level SL3 is offset from an intermediate level ML by an asymmetry quantity ASQ. The ratio S:T, i.e., the ratio of (i) the distance between negative feedback digitizing slicing level SL3 and the upper envelope RSU and (ii) the distance between negative feedback digitizing slicing level SL3 and the lower envelope RSD is referred to as an "asymmetry coefficient ASC".

[0058] In a period corresponding to the disturbance D1 caused by a defect, the negative feedback digitizing slicing level SL3 fluctuates while maintaining the asymmetry coefficient ASC=S:T. However, in a period where the disturbance D1 has an excessively short cycle, the negative feedback digitizing slicing level SL3 cannot appropriately follow the disturbance D1, resulting in a slicing error.

[0059] In order to avoid such an inconvenience, the reproduction signal processing apparatus **200A** includes the above-described elements and operates as follows.

[0060] Referring to Figure **7B,** the averaging circuit **5** sets a weighting coefficient M:N to the upper envelope RSU and the lower envelope RSD used for calculating an average value AVE1 at the asymmetry coefficient ASC (S:T) which is output from the asymmetry detection circuit **8,** and puts a weight represented by the asymmetry coefficient ASC (S:T) to each of the upper envelope RSU and the lower envelope RSD to calculate the average value AVE1.

[0061] Referring to Figure **7C,** the low pass filter **6** removes a noise component included in the average value AVE1 and outputs a smoothing signal SM2. Referring to Figure **7D,** the subtraction circuit **7** subtracts the smoothing signal SM2 from the reproduction signal RS to output a wave-shaped signal SS1.

[0062] Where the weighting coefficient M:N is set at the asymmetry coefficient ASC (S:T), the fluctuation of the negative feedback digitizing slicing level SL3 is minimized as shown in Figure **7D**. Thus, the slicing performance when the light beam passes through the defect of the optical disk **1** (Figure **1**) is further improved.

[0063] The weighting coefficient M:N can also be 1:1 when the asymmetry occurs. With such setting, the fluctuation of the negative feedback digitizing slicing level SL3 is within a range causing no practical problem, although the fluctuation is slightly larger as compared with when the weighting coefficient M:N is set at the asymmetry coefficient.

[0064] Figure **8** shows an exemplary structure of the asymmetry detection circuit **8**. The asymmetry detection circuit **8** includes a peak detection circuit **9** for detecting a peak of the reproduction signal RS, a second low pass filter **10** for detecting a DC level of the reproduction signal RS, a bottom level detection circuit **11** for detecting a bottom level of the reproduction signal RS, second subtraction circuits **12A** and **12B,** and an asymmetry coefficient calculation circuit **12C.** The asymmetry coefficient calculation circuit **12C** calculates the asymmetry coefficient ASC (S:T) based on the difference between the output from the peak detection circuit **9** and the output from the second low pass filter **10** and the difference between the output from the second low pass filter **10** and the bottom level detection circuit **11**.

[0065] At least one of a first detection time constant used by the first detection circuit **3** and a second detection time constant used by the second detection circuit **4** is determined to be substantially in proportion to the diameter of a light spot on the optical disk **1** (Figure **1**).

[0066] Figures **9A** and **9C** respectively show light spots SP1 and SP2 having diameters d1 and d2 passing through a defect DF on the optical disk **1**. In Figures **9A** and **9C,** the size of the defeat DF is the same. Figure **9B** and **9D** respectively show the fluctuation of the reproduction signal RS in the states shown in Figures **9A**

and **9C**.

[0067] The diameter d1 of the light spot SP1 is n times the diameter d2 of the light spot SP2 (n>1). When the diameter d1 is n times the diameter d2, the decreasing rate of the level of the reproduction signal RS (represented as RS1) in Figure **9B** is 1/n times the decreasing rate of the level of the reproduction signal RS (represented as RS2) in Figure **9D.** Thus, the level of the reproduction signal RS1 decreases more slowly than the reproduction signal RS2.

[0068] The first detection circuit **3** detects the reproduction signals RS1 and RS2 using detection signals DS1 and DS2, respectively. A detection time constant T1 of the detection signal DS1 is determined to be n times a detection time constant T2 of the detection signal DS2. As can be appreciated from this, the detection time constant used by the first detection circuit **3** is determined to be substantially in proportion to the diameter of the light spot. The detection time constant used by the second detection circuit **4** is also determined to be substantially in proportion to the diameter of the light spot.

[0069] The detection time constants T1 and T2 are determined so as to detect a decrease in the level of the reproduction signals RS1 and RS2. Therefore, the detection time constants T1 and T2 can be determined to be short so long as the slopes of the detection signals DS1 and DS2 shown in Figures **9B** and **9D** are obtained.

[0070] It should be noted that when the detection time constant is determined to be excessively short so that a rapidly decreasing reproduction signal level is detected, unnecessary noise is picked up. Accordingly, the detection time constant is determined to be appropriate in consideration of the dimensions of the light spot.

[0071] It is preferable to determine the detection time constant to be substantially in proportion to the diameter of the light spot. In this case, the slicing performance obtained when the light beam passes through the defect of the optical disk **1** (Figure **1**) is improved while the generation of jitters when the optical disk **1** has no defect is not deteriorated without picking up the unnecessary noise.

[0072] The detection time constant used by the first detection circuit **3** or the second detection circuit **4** can be determined so as to be substantially in inverse proportion to the reproduction linear velocity. Figures **10A** and **10B** show fluctuations of the reproduction signal RS when the light beam passes through the defect of the optical disk **1** (Figure **1**), with different linear velocities of the same defect. Figure **10A** shows the fluctuation when the optical disk 1 is reproduced at the normal speed, and Figure **10B** shows the fluctuation when the optical disk **1** is reproduced at the speed of n times the normal speed.

[0073] As can be appreciated from the comparison between Figure **10A** and Figure **10B**, when the linear velocity is n times higher, the decreasing rate of the level of the reproduction signal RS is also n times higher, and accordingly the optimum detection time constant is 1/n. In this manner, the detection time constant is determined to be substantially in inverse proportion to the reproduction linear velocity.

[0074] The cutoff frequency of the low pass filter **6** can be determined to be substantially in inverse proportion to the diameter of the light spot on the optical disk **1** (Figures **9A** and **9C**). As shown in Figures **9A** and **9B,** when the diameter of the light spot is n times larger, the decreasing rate of the level of the reproduction signal RS is 1/n. When the diameter of the light spot is 1/n, the decreasing rate of the level of the reproduction signal RS is n times higher.

[0075] When the decreasing rate of the level of the reproduction signal RS is n times higher, the frequency of the hazardous DC fluctuation component (Figure **7C**) included in the smoothing signal SM2 becomes n times higher. In order to allow the fluctuation component having the frequency of n times higher to pass through the low pass filter **6**, the cutoff frequency of the low pass filter **6** needs to be set at n times higher.

[0076] Accordingly; when the diameter of the light spot is 1/n, the cutoff frequency of the low pass filter **6** is set at n times higher. In this manner, the cutoff frequency of the low pass filter **6** is determined to be substantially in inverse proportion to the diameter of the light spot.

[0077] In this case, the slicing performance obtained when the light beam passes through the defect of the optical disk **1** (Figure **1**) is improved while the generation of jitters when the optical disk **1** has no defect is not deteriorated.

[0078] The cutoff frequency of the low pass filter **6** can be determined to be substantially in proportion to the reproduction linear velocity. As shown in Figure **10B**, when the reproduction linear velocity is n times higher, the decreasing rate of the level of the reproduction signal RS obtained when the light beam passes through the defect of the optical disk **1** is also n times higher.

[0079] When the decreasing rate of the level of the reproduction signal RS is n times higher, the frequency of the hazardous DC fluctuation component (Figure **7C**) included in the smoothing signal SM2 becomes n times higher. In order to allow the fluctuation component having the frequency of n times higher to pass through the low pass filter **6**, the cutoff frequency of the low pass filter **6** needs to be set at n times higher.

[0080] Accordingly, when the reproduction linear velocity is n times higher, the cutoff frequency of the low pass filter **6** is set at n times higher. In this manner, the cutoff frequency of the low pass filter **6** is determined to be substantially in proportion to the reproduction linear velocity.

[0081] In this case, the slicing performance obtained when the light beam passes through the defect of the optical disk **1** (Figure **1**) is improved while the generation of jitters when the optical disk **1** has no defect is not deteriorated.

(Example 3)

[0082] Figure **11** is a block diagram of a reproduction signal processing apparatus **200B** in a third example according to the present invention. Identical elements previously discussed with respect to Figure **1** bear identical reference numerals and the descriptions thereof will be omitted. The reproduction signal processing apparatus **200B** includes a wave-shaping apparatus **100B** and the digitizing circuit **1300.**

[0083] The wave-shaping apparatus **100B** includes a dropout detection circuit **13** for detecting a dropout indicating a decrease in the amplitude of the reproduction signal RS in addition to the elements shown in Figure **1**.

[0084] When the dropout detection circuit **13** detects a dropout, at least one of the first detection time constant used by the first detection circuit **3** and the second detection time constant used by the second detection circuit **4** is determined to be shorter than the time constant when no dropout is detected. Accordingly, when a dropout is detected, a negative feedback digitizing slicing level can follow a disturbance more accurately in a period corresponding to the disturbance caused by a defect. When no dropout is detected (normal reproduction), the noise or the like generated in the first or second detection circuit **3** or **4** is suppressed. Accordingly, the slicing performance obtained when the light beam passes through the defect of the optical disk **1** (Figure **1**) is improved while the generation of jitters when the optical disk **1** has no defect is not deteriorated.

[0085] Figure **12** is a block diagram of another reproduction signal processing apparatus **200C** in the third example according to the present invention. Identical elements previously discussed with respect to Figure **11** bear identical reference numerals and the descriptions thereof will be omitted. The reproduction signal processing apparatus **200C** includes a wave-shaping apparatus **100C** and the digitizing circuit **1300.**

[0086] When the dropout detection circuit **13** detects a dropout, the cutoff frequency of the low pass filter **6** is set at higher than the time constant when no dropout is detected. Accordingly, when a dropout is detected, a hazardous DC fluctuation component generated in a period corresponding to a disturbance caused by a defect is allowed to pass through the low pass filter **6**. When no dropout is detected (normal reproduction), the noise or the like generated in the first or second detection circuit **3** or **4** is suppressed. Accordingly, the slicing performance obtained when the light beam passes through the defect of the optical disk **1** (Figure **1**) is improved while the generation of jitters when the optical disk **1** has no defect is not deteriorated.

[0087] As described above, the present invention provides a wave-shaping apparatus and a reproduction signal processing apparatus, which accurately digitizes a reproduction signal even when the level of the reproduction signal obtained from an optical disk significantly fluctuates by a defect on the optical disk as well as when the optical disk has no defect. Thus, the wave-shaping apparatus and the reproduction signal processing apparatus according to the present invention alleviate the load of a digitizing circuit and significantly decrease the generation of jitters.

[0088] Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

Claims

1. A wave-shaping apparatus, comprising:

- a first detection circuit (3) for detecting a reproduction signal (RS) reproduced from an optical disk (1) by an optical pickup circuit (2) using a first detection time constant to detect an upper envelope (RSU) of the reproduction signal (RS);
- a second detection circuit (4) for detecting the reproduction signal (RS) using a second detection time constant to detect a lower envelope (RSD) of the reproduction signal (RS);
- an averaging circuit (5) for putting a weight represented by a weighting coefficient (M:N) to each of the upper envelope (RSU) and the lower envelope (RSD) to calculate an average value (AVE) of each of the upper envelope (RSU) and the lower envelope (RSD);
- a low pass filter (6) for extracting a DC fluctuation component, caused by a defect on the optical disk (1), included in the reproduction signal (RS) and for smoothing the average value (AVE), so as to output a signal containing the extracted component as a smoothing signal (SM1); and
- a subtraction circuit (7) for subtracting the smoothing signal (SM1) corresponding to the average value (AVE) from the reproduction signal (RS) to output a wave-shaped signal (SS);

wherein at least one of the first detection time constant and the second detection time constant is determined to be substantially in proportion to a diameter of a light spot on the optical disk.

2. A wave-shaping apparatus, comprising:

- a first detection circuit (3) for detecting a reproduction signal (RS) reproduced from an optical disk (1) by an optical pickup circuit (2) using a first detection time constant to detect an upper envelope (RSU) of the reproduction signal

(RS);

- a second detection circuit (4) for detecting the reproduction signal (RS) using a second detection time constant to detect a lower envelope (RSD) of the reproduction signal (RS);
- an averaging circuit (5) for putting a weight represented by a weighting coefficient (M:N) to each of the upper envelope (RSU) and the lower envelope (RSD) to calculate an average value (AVE) of each of the upper envelope (RSU) and the lower envelope (RSD);
- a low pass filter (6) for extracting a DC fluctuation component, caused by a defect on the optical disk (1), included in the reproduction signal (RS) and for smoothing the average value (AVE), so as to output a signal containing the extracted component as a smoothing signal (SM1); and
- a subtraction circuit (7) for subtracting the smoothing signal (SM1) corresponding to the average value (AVE) from the reproduction signal (RS) to output a wave-shaped signal (SS);

wherein at least one of the first detection time constant and the second detection time constant is determined to be substantially in inverse proportion to a reproduction linear velocity of the optical disk.

3. A wave-shaping apparatus, comprising:

- a first detection circuit (3) for detecting a reproduction signal (RS) reproduced from an optical disk (1) by an optical pickup circuit (2) using a first detection time constant to detect an upper envelope (RSU) of the reproduction signal (RS);
- a second detection circuit (4) for detecting the reproduction signal (RS) using a second detection time constant to detect a lower envelope (RSD) of the reproduction signal (RS);
- an averaging circuit (5) for putting a weight represented by a weighting coefficient (M:N) to each of the upper envelope (RSU) and the lower envelope (RSD) to calculate an average value (AVE) of each of the upper envelope (RSU) and the lower envelope (RSD);
- a low pass filter (6) for extracting a DC fluctuation component, caused by a defect on the optical disk (1), included in the reproduction signal (RS) and for smoothing the average value (AVE), so as to output a signal containing the extracted component as a smoothing signal (SM1); and
- a subtraction circuit (7) for subtracting the smoothing signal (SM1) corresponding to the average value (AVE) from the reproduction signal (RS) to output a wave-shaped signal (SS);

wherein a cutoff frequency of the low pass filter (6) is determined to be substantially in inverse proportion to a diameter of a light spot on the optical disk.

4. A wave-shaping apparatus, comprising:

- a first detection circuit (3) for detecting a reproduction signal (RS) reproduced from an optical disk (1) by an optical pickup circuit (2) using a first detection time constant to detect an upper envelope (RSU) of the reproduction signal (RS);
- a second detection circuit (4) for detecting the reproduction signal (RS) using a second detection time constant to detect a lower envelope (RSD) of the reproduction signal (RS);
- an averaging circuit (5) for putting a weight represented by a weighting coefficient (M:N) to each of the upper envelope (RSU) and the lower envelope (RSD) to calculate an average value (AVE) of each of the upper envelope (RSU) and the lower envelope (RSD);
- a low pass filter (6) for extracting a DC fluctuation component, caused by a defect on the optical disk (1), included in the reproduction signal (RS) and for smoothing the average value (AVE), so as to output a signal containing the extracted component as a smoothing signal (SM1); and
- a subtraction circuit (7) for subtracting the smoothing signal (SM1) corresponding to the average value (AVE) from the reproduction signal (RS) to output a wave-shaped signal (SS);

wherein a cutoff frequency of the low pass filter (6) is determined to be substantially in proportion to a reproduction linear velocity of the optical disk.

FIG. 1

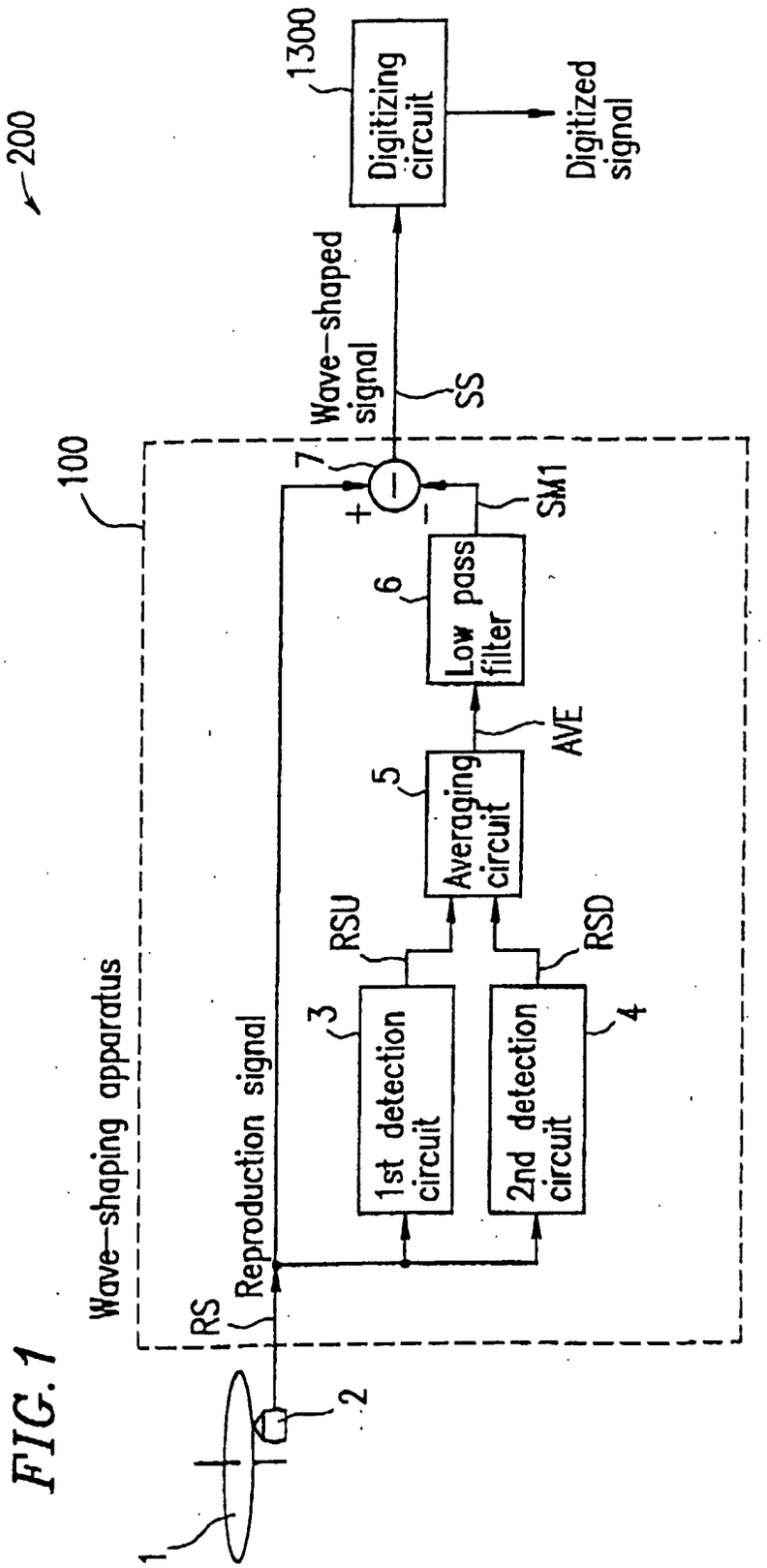

200
1300
Digitizing circuit
Digitized signal
Wave-shaped signal
SS
100
7
+
−
SM1
6
Low pass filter
AVE
5
Averaging circuit
RSU
RSD
3
1st detection circuit
4
2nd detection circuit
Wave-shaping apparatus
RS
Reproduction signal
1
2

FIG. 2A

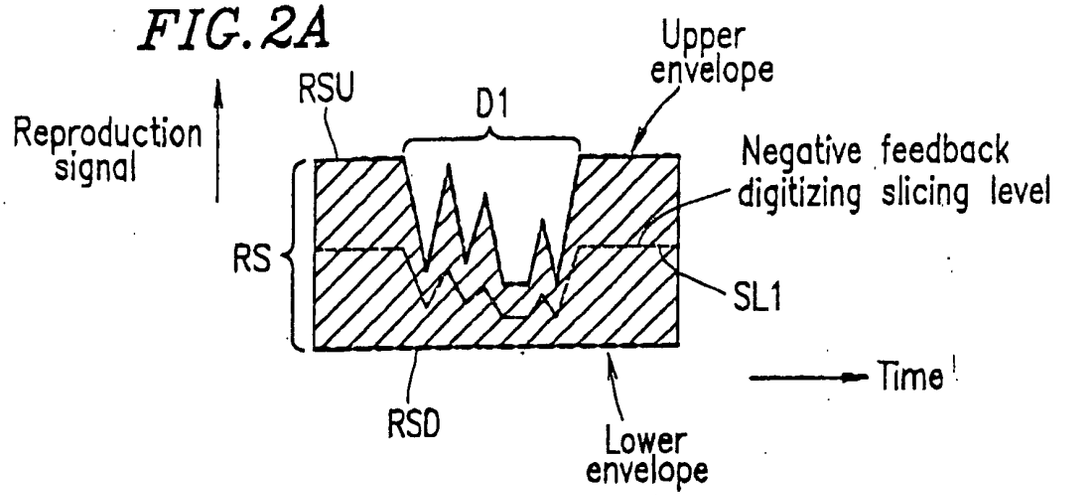


FIG. 2B

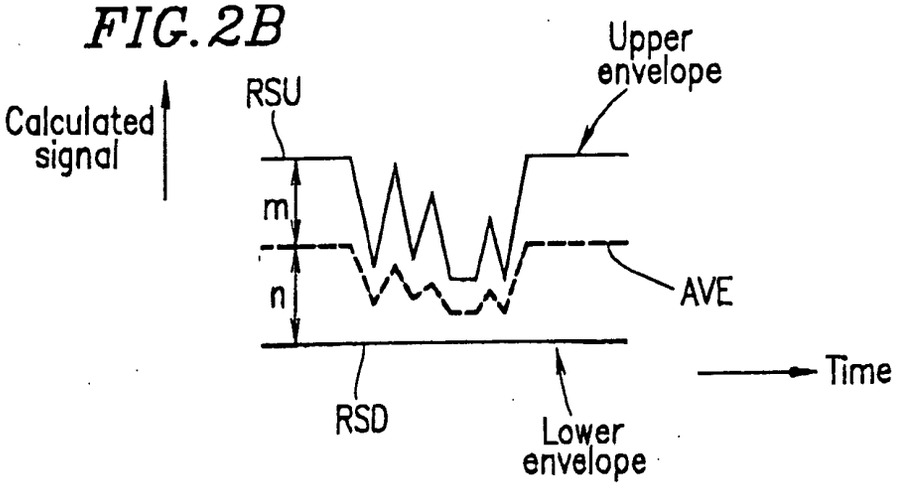


FIG. 2C

FIG. 2D

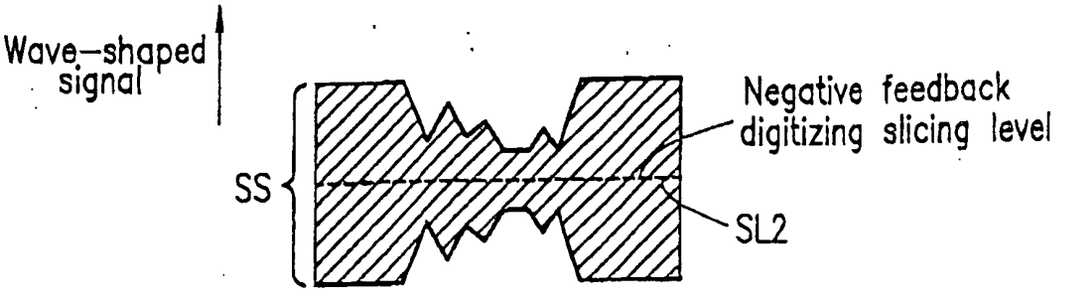


FIG. 3

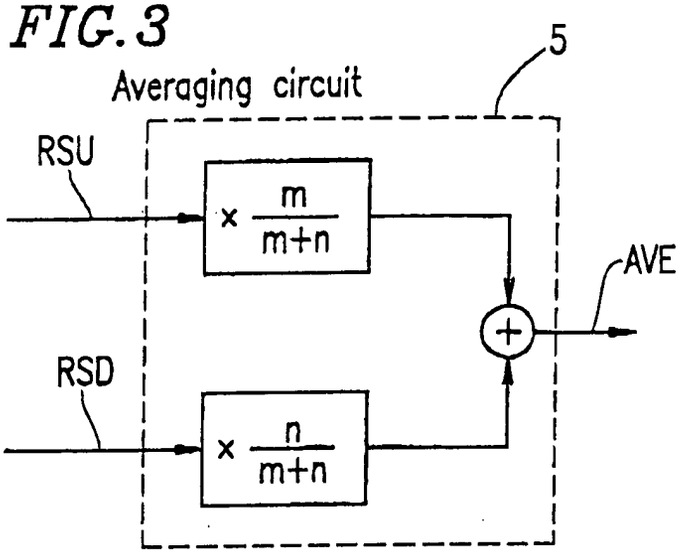


FIG. 4A

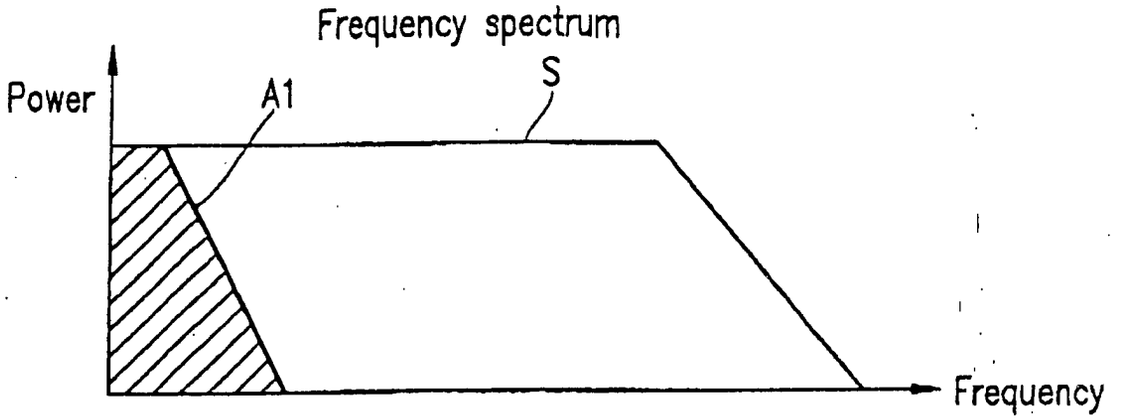

Frequency spectrum
Power
A1
S
Frequency

FIG. 4B

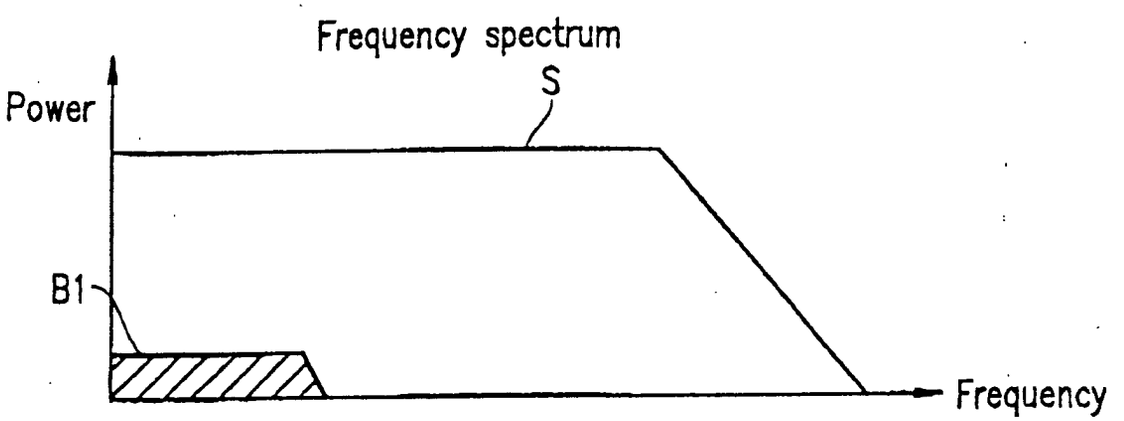

Frequency spectrum
Power
S
B1
Frequency

FIG. 5

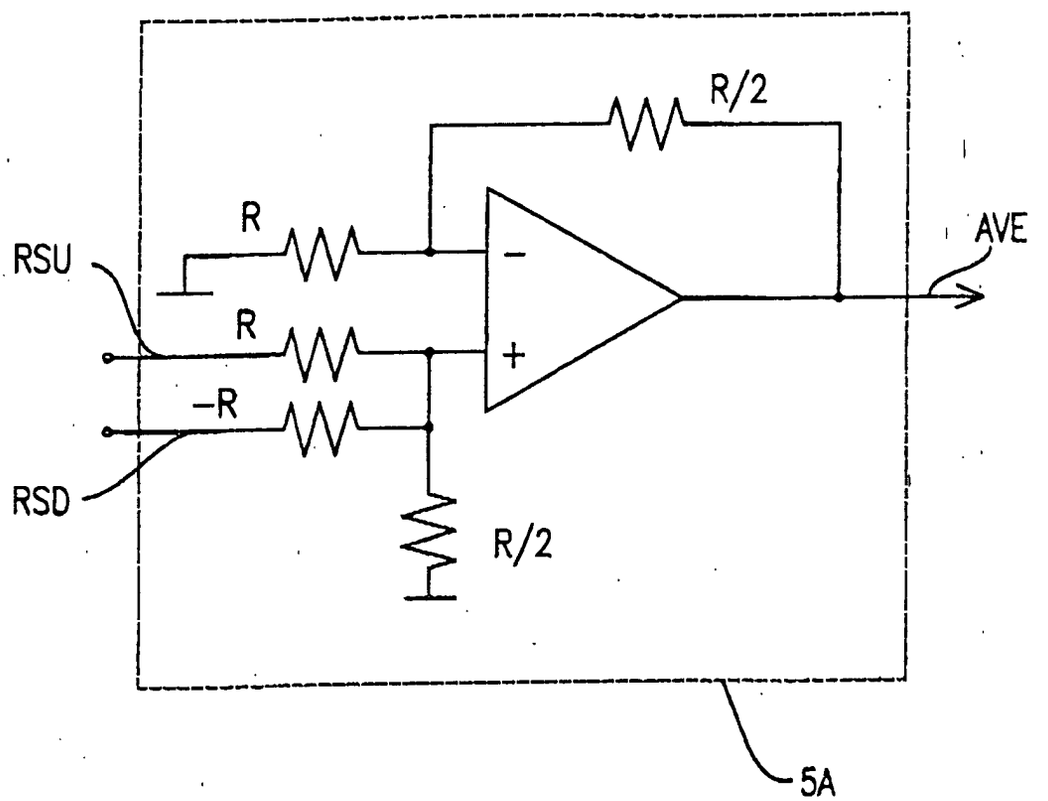


FIG. 6

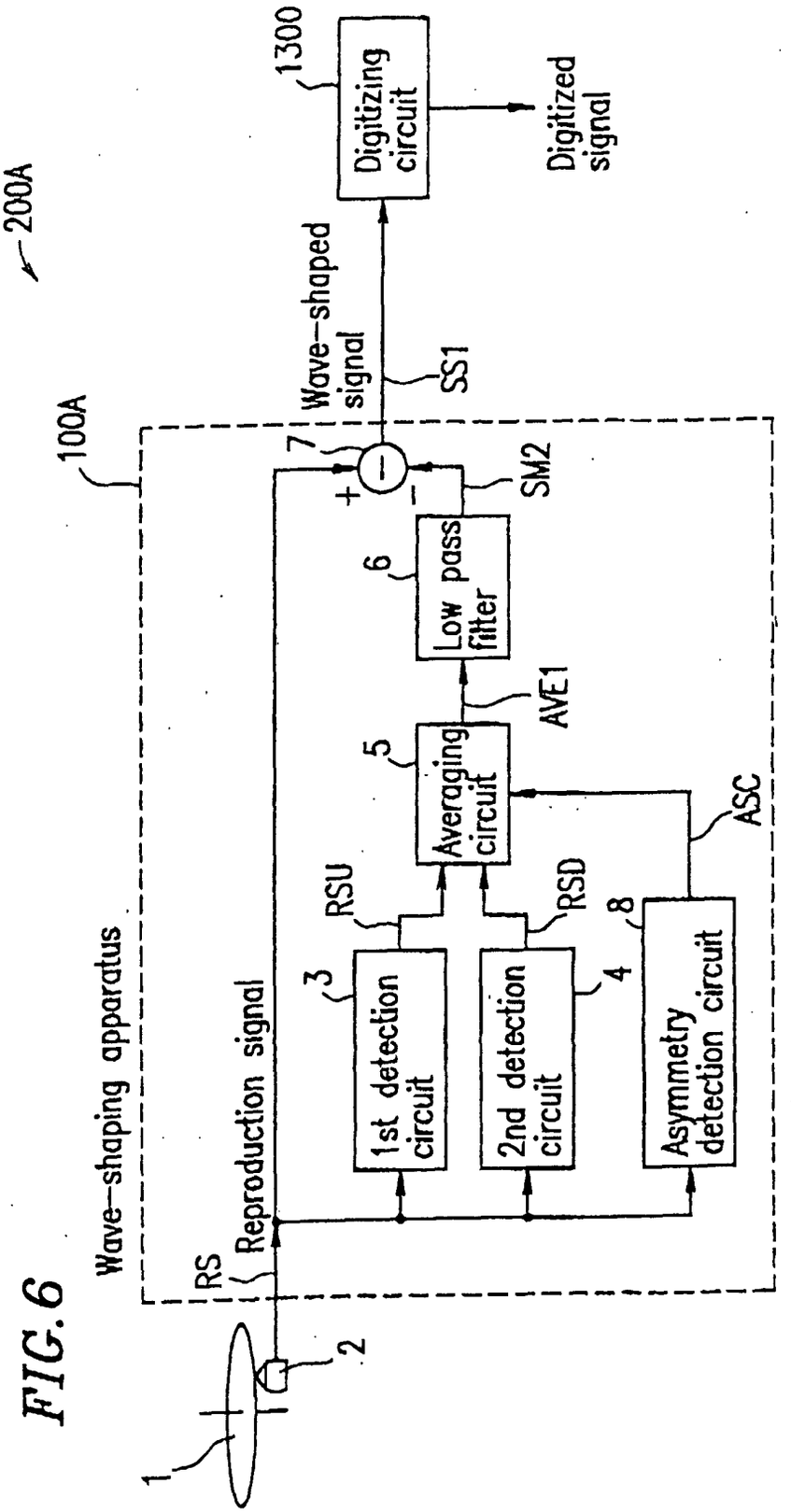

200A
1300
Digitizing circuit
Digitized signal
Wave-shaped signal
SS1
100A
7
+
−
SM2
6
Low pass filter
AVE1
5
Averaging circuit
ASC
RSU
RSD
8
3
4
1st detection circuit
2nd detection circuit
Asymmetry detection circuit
Wave-shaping apparatus
RS
Reproduction signal
2
1

FIG. 7A

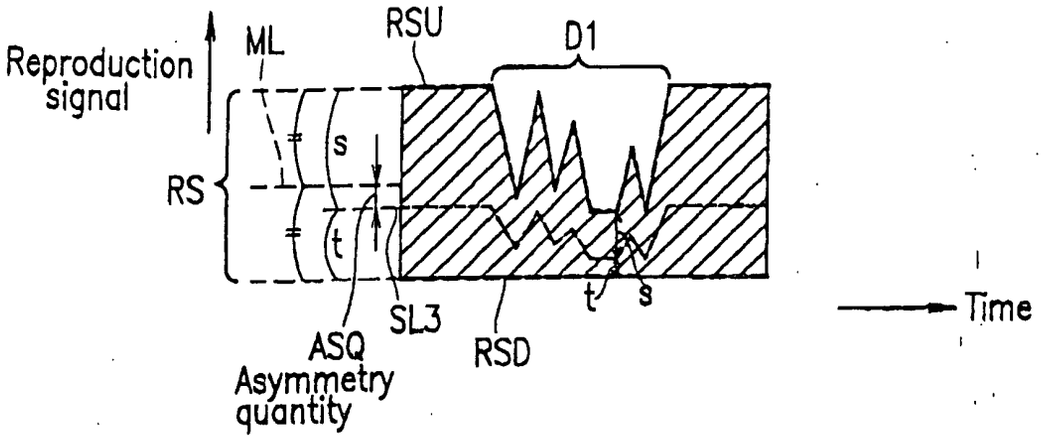


FIG. 7B

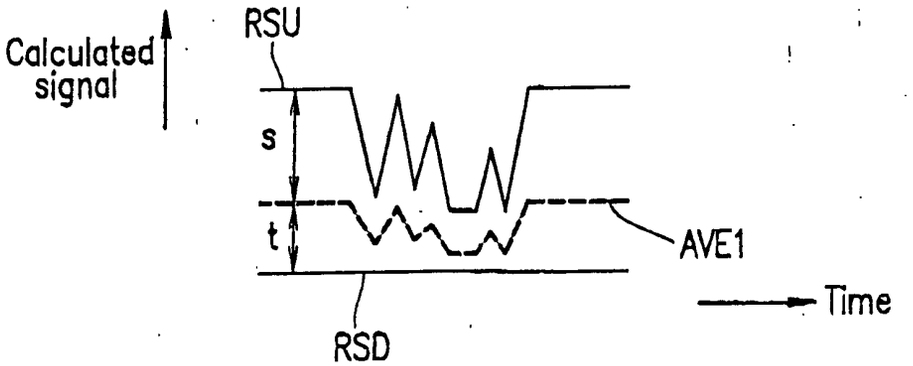


FIG. 7C

FIG. 7D

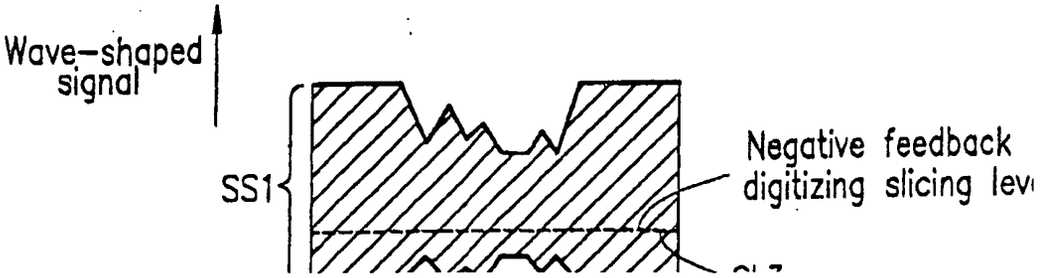


FIG. 8

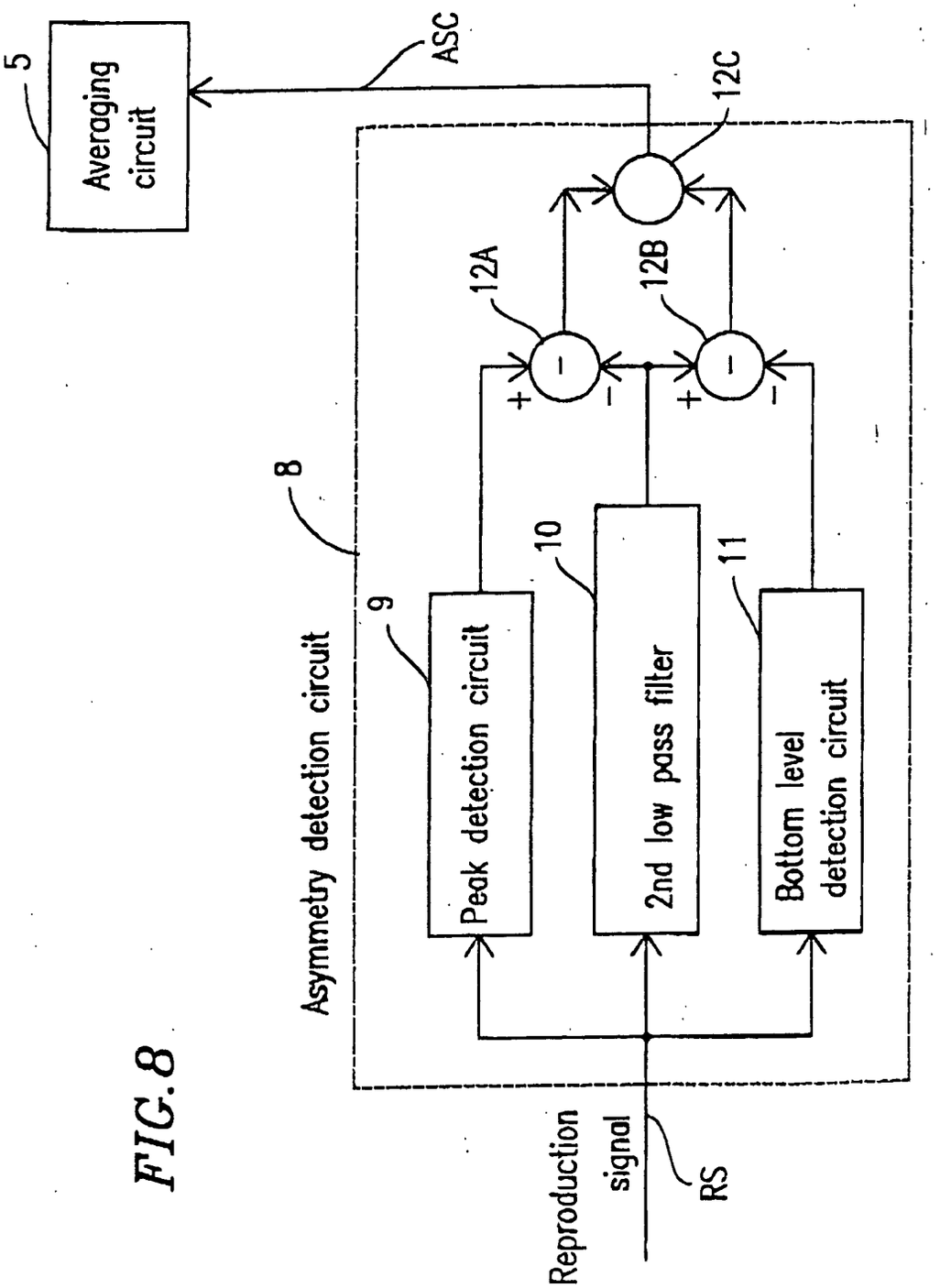

5
Averaging circuit
ASC
12C
12A
12B
8
Asymmetry detection circuit
9
Peak detection circuit
10
2nd low pass filter
11
Bottom level detection circuit
Reproduction signal
RS

FIG. 9A

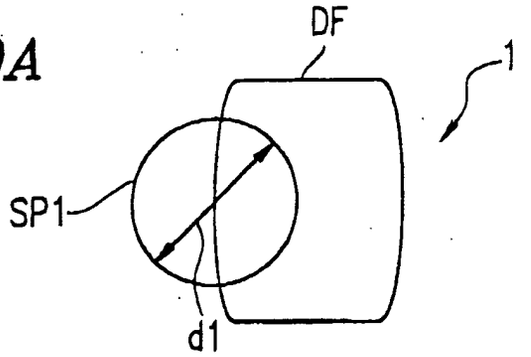


FIG. 9B

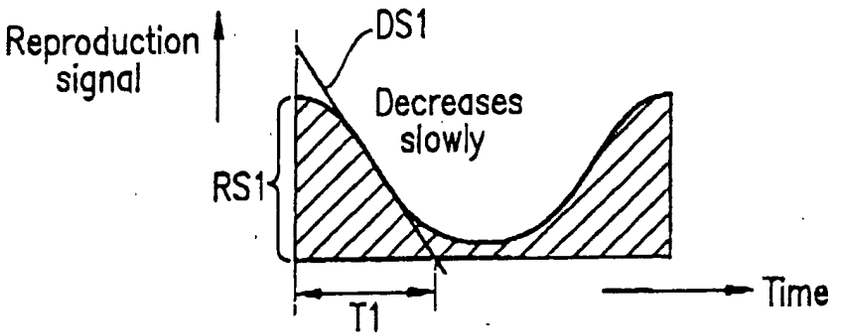


FIG. 9C

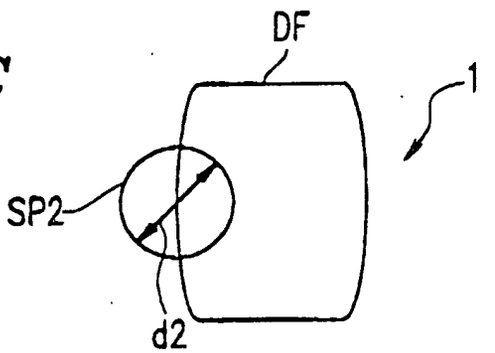


FIG. 9D

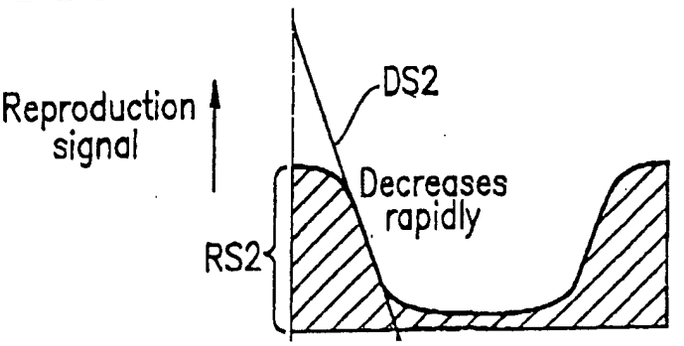


FIG. 10A

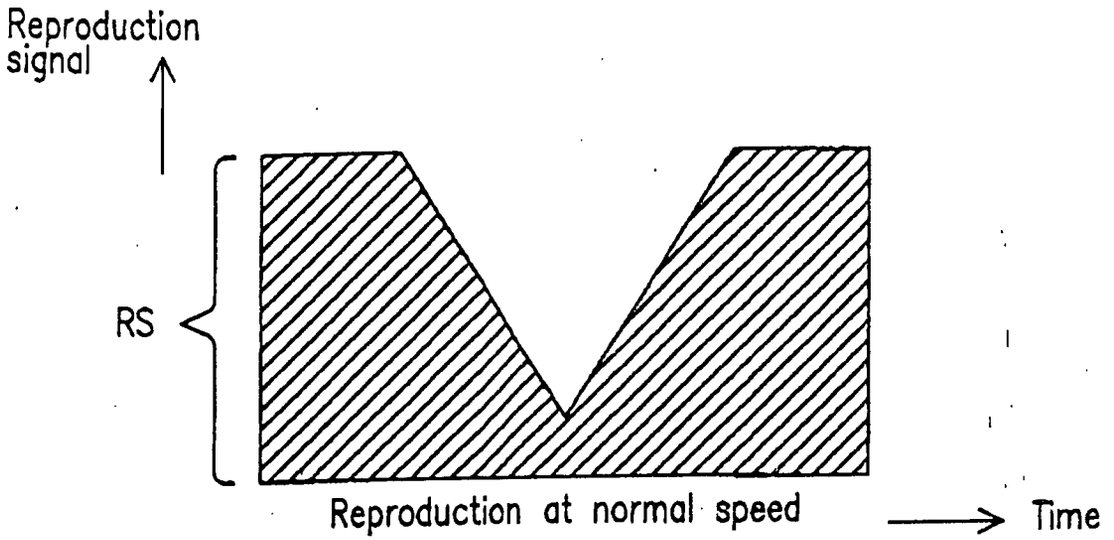


FIG. 10B

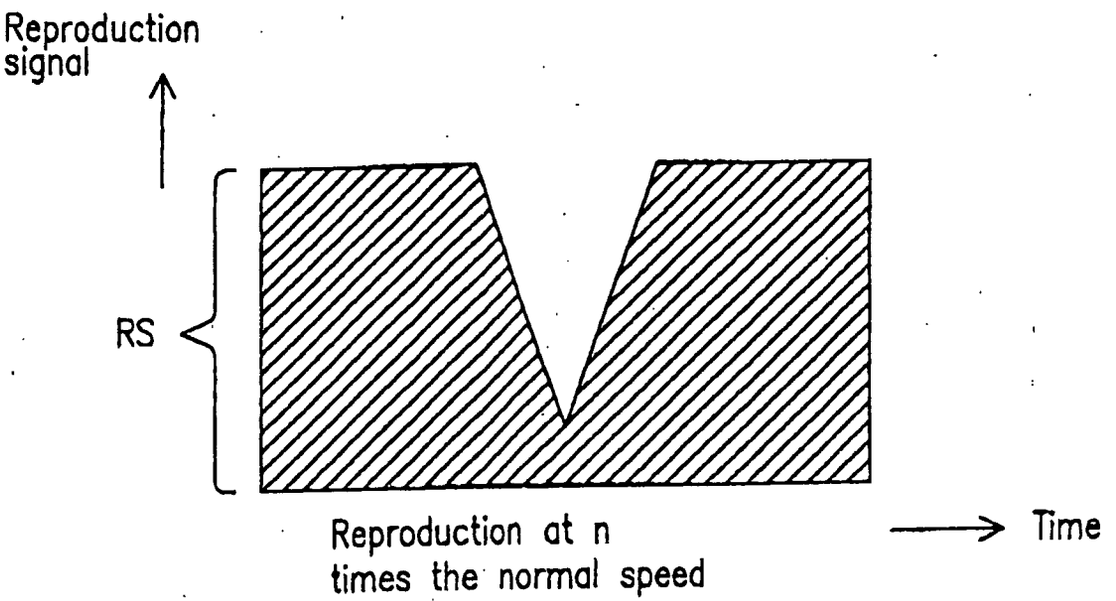


FIG. 11

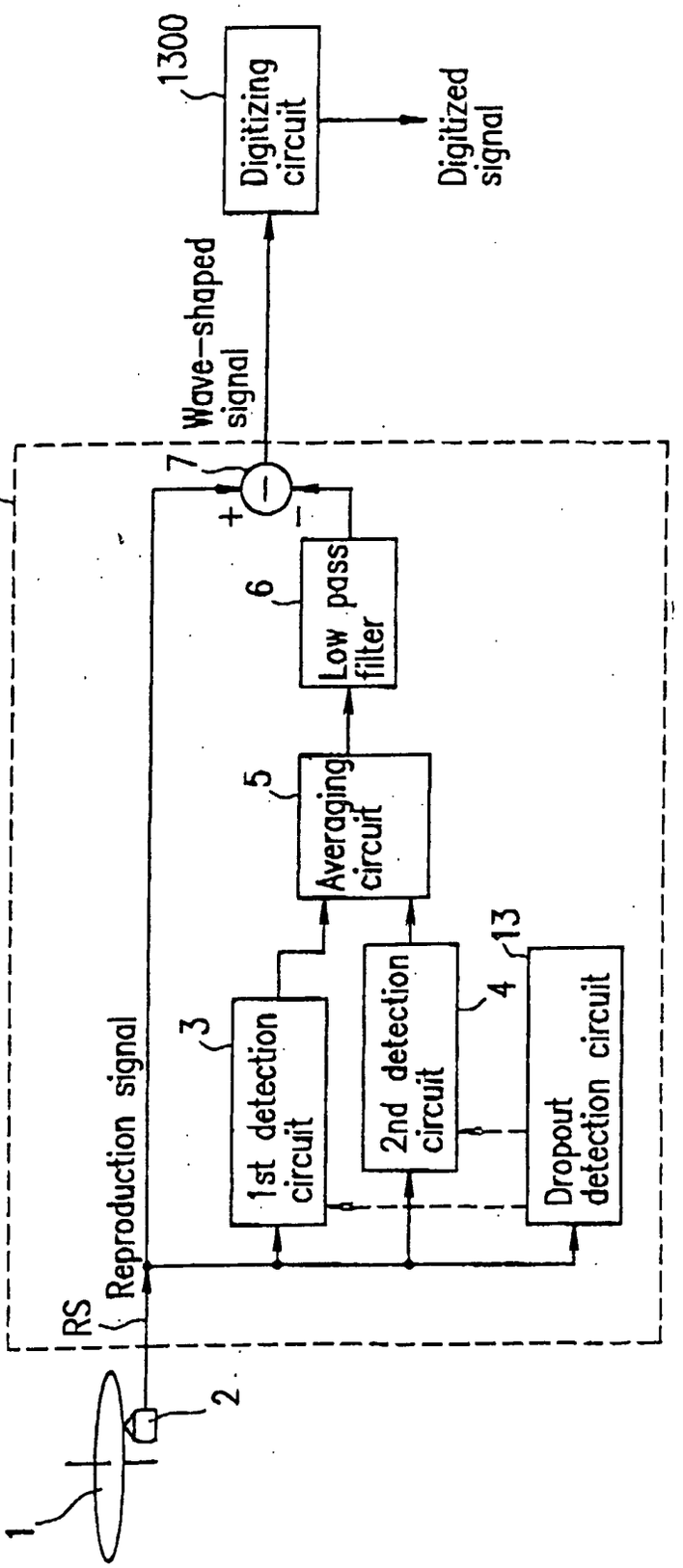

200B
100B
Wave-shaping apparatus
1
2
RS
Reproduction signal
3
1st detection circuit
4
2nd detection circuit
13
Dropout detection circuit
5
Averaging circuit
6
Low pass filter
7
+
−
Wave-shaped signal
1300
Digitizing circuit
Digitized signal

FIG. 12

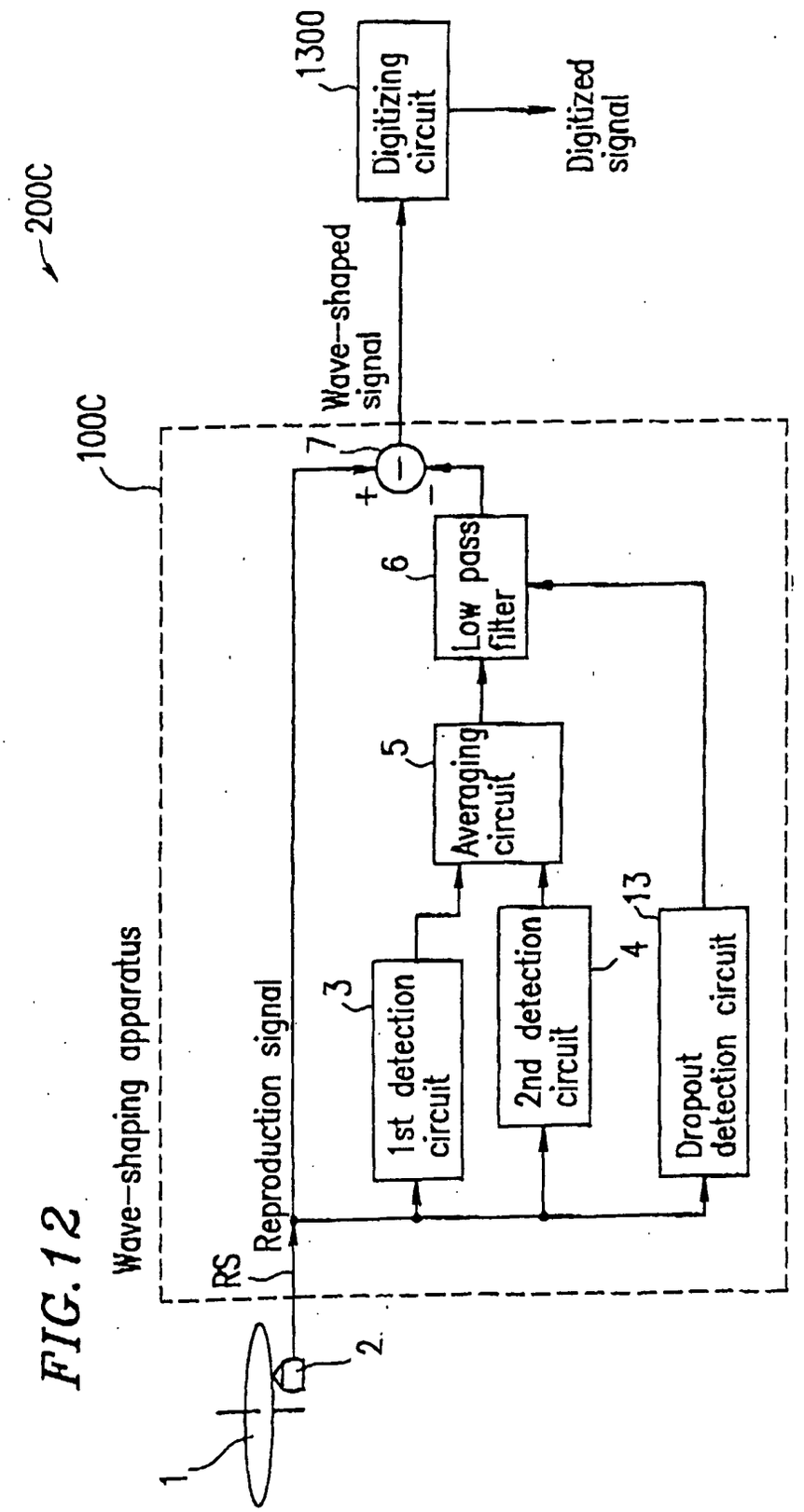

200C
100C
Wave-shaping apparatus
1300
Digitizing circuit
Digitized signal
Wave-shaped signal
7
+
−
6
Low pass filter
5
Averaging circuit
3
1st detection circuit
4
2nd detection circuit
13
Dropout detection circuit
RS
Reproduction signal
1
2

FIG. 13A

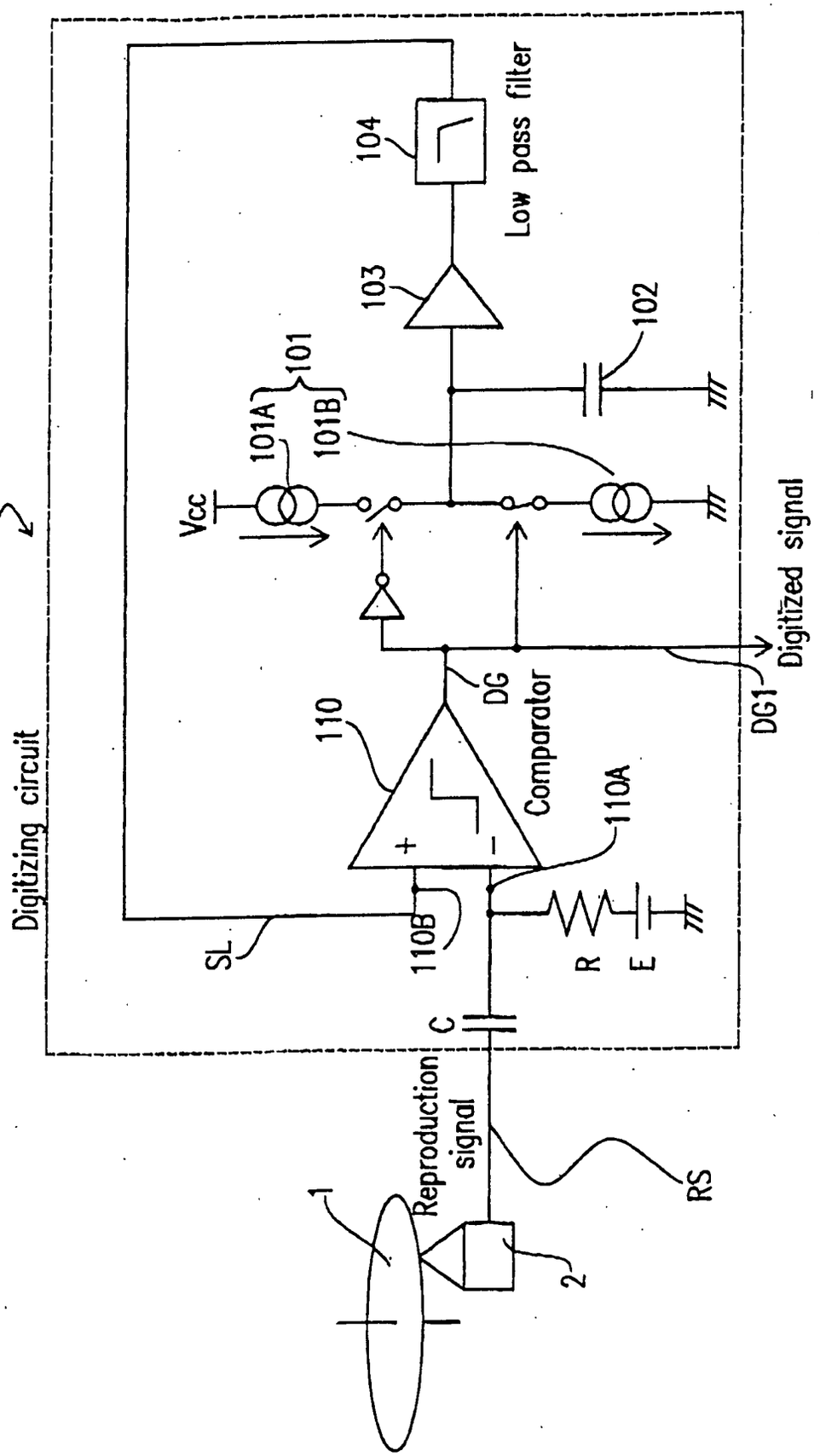

1300
Digitizing circuit
Low pass filter
104
103
102
101
101A
101B
Vcc
DG
DG1
Digitized signal
110
Comparator
110A
110B
SL
R
E
C
Reproduction signal
RS
1
2

FIG. 13B

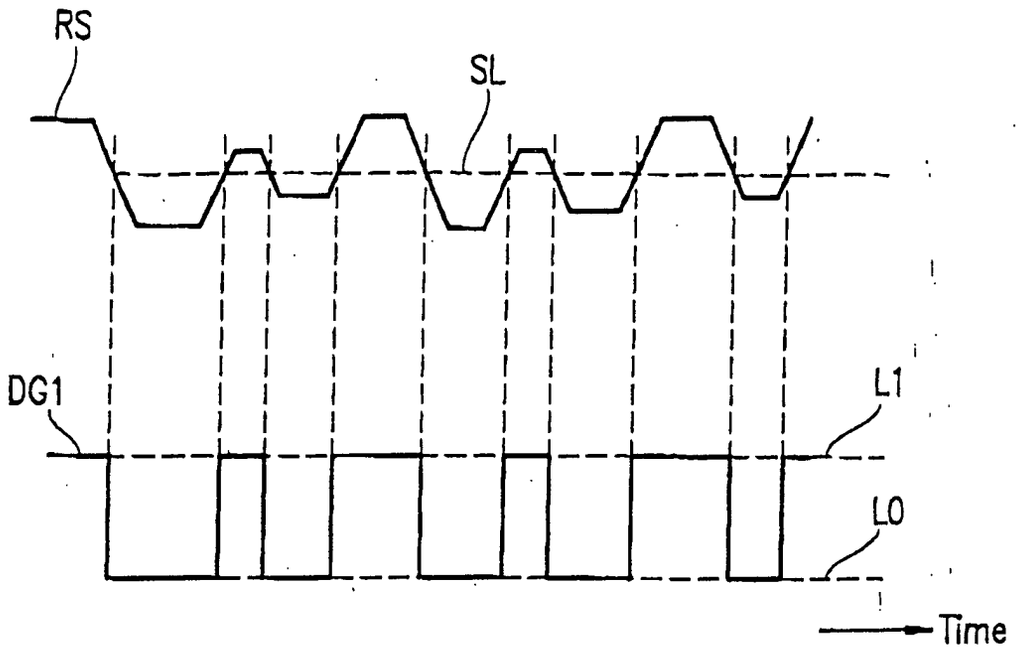
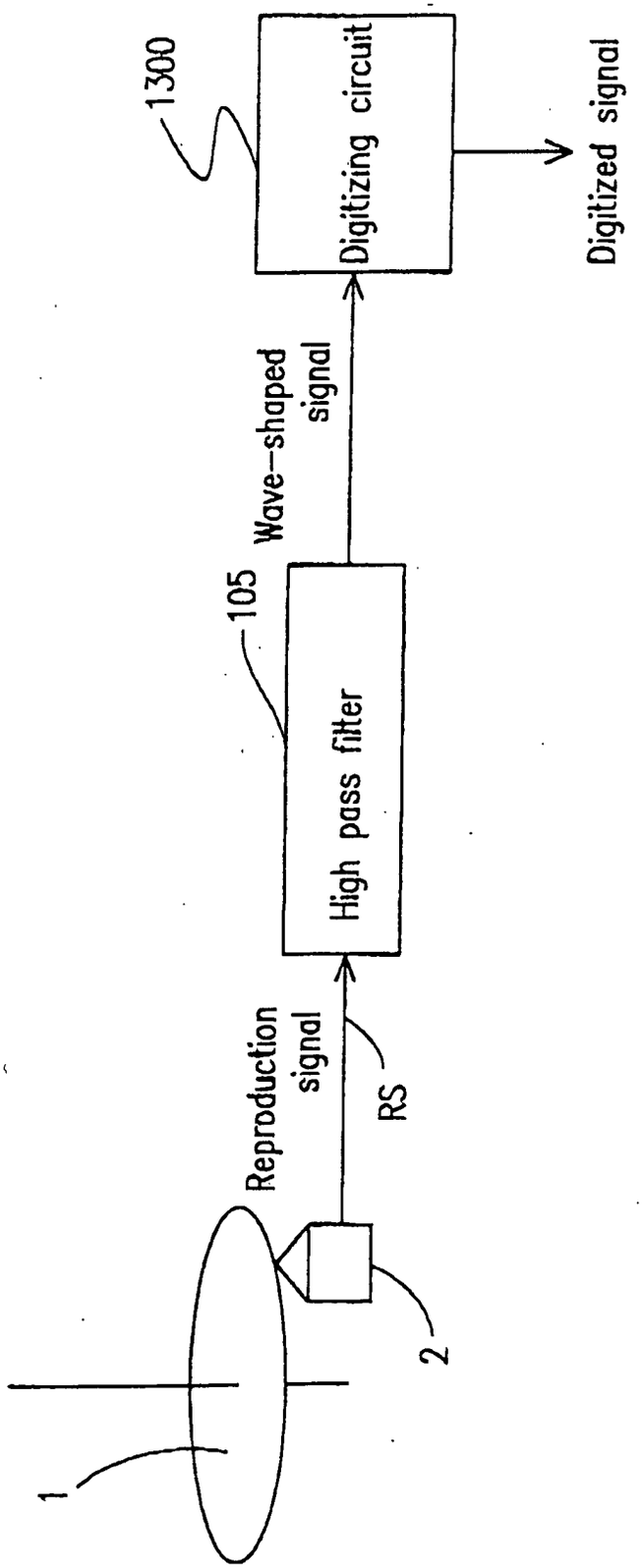


FIG. 14


1300
Digitizing circuit
Digitized signal
Wave-shaped signal
105
High pass filter
Reproduction signal
RS
1
2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 00 0514

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 051 343 A (NORTH AMERICAN PHILIPS CORPORATION) 12 May 1982 (1982-05-12) * page 2, line 21 - page 10, line 2; figure 7 *	1-4	G11B20/10
A	US 5 790 495 A (DISCOVISION ASSOCIATES) 4 August 1998 (1998-08-04) * column 2, line 36 - column 2, line 64; figure 7 * * column 9, line 5 - column 9, line 30 *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 1, 30 January 1998 (1998-01-30) & JP 09 237459 A (SANYO ELECTRIC), 9 September 1997 (1997-09-09) * abstract *	1-4	
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 9, 31 July 1998 (1998-07-31) & JP 10 106160 A (SANYO ELECTRIC), 24 April 1998 (1998-04-24) * abstract *	1-4	TECHNICAL FIELDS SEARCHED (Int.Cl.7) G11B
A	US 4 829 499 A (RICOH COMPANY) 9 May 1989 (1989-05-09) * column 2, line 14 - column 2, line 26 *	1-4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 February 2003	Van Staveren, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 00 0514

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-02-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 51343 A	12-05-1982	DE 3173778 D1	27-03-1986
		EP 0051343 A2	12-05-1982
		JP 57105830 A	01-07-1982
US 5790495 A	04-08-1998	AU 705350 B2	20-05-1999
		AU 1783595 A	23-11-1995
		AU 2601399 A	24-06-1999
		AU 2601499 A	24-06-1999
		AU 2601599 A	01-07-1999
		AU 2601699 A	24-06-1999
		CA 2148748 A1	07-11-1995
		CA 2259838 A1	07-11-1995
		CN 1120214 A	10-04-1996
		CN 1239297 A	22-12-1999
		CN 1239298 A	22-12-1999
		CN 1245955 A	01-03-2000
		CN 1239299 A	22-12-1999
		CN 1239300 A	22-12-1999
		EP 0692787 A2	17-01-1996
		EP 0817186 A2	07-01-1998
		EP 0817187 A2	07-01-1998
		EP 0817188 A2	07-01-1998
		EP 0817189 A2	07-01-1998
		EP 0817190 A2	07-01-1998
		JP 2988846 B2	13-12-1999
		JP 8111042 A	30-04-1996
		JP 11259864 A	24-09-1999
		JP 11259865 A	24-09-1999
		JP 11259866 A	24-09-1999
		JP 11259867 A	24-09-1999
		SG 33355 A1	18-10-1996
		US 5894468 A	13-04-1999
		US 5659535 A	19-08-1997
		US 5706267 A	06-01-1998
JP 09237459 A	09-09-1997	NONE	
JP 10106160 A	24-04-1998	NONE	
US 4829499 A	09-05-1989	JP 2534988 B2	18-09-1996
		JP 62257630 A	10-11-1987

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82